9 Testing of Asphalt Concrete Mixtures

This chapter of the guide covers the methods used to determine asphalt concrete properties by laboratory testing. In a hot mix asphalt (HMA) paving mixture, asphalt and aggregate are blended together in precise proportions. The relative proportions of these materials determine the physical properties of the mix, and ultimately, how the mix will perform as a finished pavement.

The Department (VDOT) establishes the mix design requirements. Once these are established, it is the responsibility of the Contractor/Producer and his Technician to develop the mix within the framework of the specifications.

Learning Objectives:

Upon completion of this chapter, you should be able to:

- ☑ Identify the laboratory tests used to determine asphalt characteristics
- ☑ Define VTM, VMA, VFA, and the F/A ratio, and describe how each is calculated
- ☑ Describe how to perform the Bulk Specific Gravity and Maximum Specific Gravity procedures
- ☑ Perform volumetric calculations

Overview

	DEFINITIONS. The following terms will be used throughout this section:
Percent Binder (P_b)	The percent of asphalt binder in the mix by mass (as a percent of the total mix mass).
Specific Gravity	A unit-less ratio of a material's density relative to water when both are at the same temperature (i.e., if we say a material has a specific gravity of 2, then it has twice the mass of water for a given volume).
Voids in the Total Mixture (VTM)	The part of the compacted mixture not occupied by aggregate or asphalt, expressed as a percentage of the total volume. VTM is synonymous with air voids.
Voids Filled with Asphalt (VFA)	The percentage of voids in the compacted aggregate mass that are filled with asphalt cement; also known as the Asphalt Void Ratio.
Voids in the Mineral Aggregate (VMA)	The air void spaces that exist between the aggregate particles in a compacted paving mixture, including spaces filled with asphalt.
Fines to Asphalt Ratio (F/A)	Indicates the film thickness of coated particles.
Tensile Strength Ratio (TSR)	Measures the strength loss resulting from damage caused by stripping under laboratory-controlled accelerated freeze-thaw conditioning.

Through many years of laboratory testing and actual road application, VDOT has established design ranges based on the Superpave Mix Design system for asphalt concrete mixtures used in Virginia. When a sample of HMA is tested in the laboratory, it can be analyzed to determine its probable performance in the pavement structure, as well as its conformance to VDOT specifications.

The laboratory tests used to ensure that asphalt concrete mixtures meet specifications, and what they physically determine, are indicated in the table that follows. All of the tests listed in the table will be addressed in this chapter, with the exception of Sieve Analysis (which was covered in Chapter 6). Only after the physical characteristics have been determined using these tests can we complete volumetric calculations.

Note: Throughout this section, in the text and particularly in the volumetric equations, we will refer to the Asphalt Content as the Percent Binder (P_b).

Use This Laboratory Test…	To Determine the Physical Characteristic…
Ignition Method	The Percent Binder (P_b) in the mix
Specific Gravity	The ratio of a material's density relative to water
Maximum Specific Gravity (Rice, MSG, or G_{mm})	A mixture's specific gravity in a void-less condition, which would be the max achievable specific gravity for that mix
Bulk Specific Gravity of Mixture (G_{mb})	The volume of voids in the mix of a compacted specimen. Note: G_{mm} must be greater than G_{mb} for a given mix.
Sieve Analysis	Particle size distribution of aggregates in asphalt
Tensile Strength Ratio (TSR)	Stripping potential

Other tests that may be performed in the lab include the Boil Test, Moisture Content Test, Particle Coating Test, and Aggregate Consensus Properties Test. Of these, the Boil Test is covered in this chapter. The Moisture Content test was previously covered in Chapter 3 of this guide.

Figure 9-1 illustrates design ranges and Figure 9-2 provides recommended performance grades for the asphalt concrete mixtures used in Virginia (Road and Bridge Specifications, Section 211, Table II-14 and II-14A).

Table II-14. Mix Design Criteria

Mix Type	VTM (%) Production (Note 1)	VFA (%) Design	VFA (%) *Production* (Note 2)	Min. VMA (%)	Fines/Asphalt Ratio (Note 3)	N Design	N Initial	N Max	Density (%) at N Initial
SM-9.0 A [Notes 1,2,3]	2.0-5.0	75-80	70-85	16	0.6-1.3	65	7	100	≤ 90.5
SM-9.0 D [Notes 1,2,3]	2.0-5.0	75-80	70-85	16	0.6-1.3	65	7	100	≤ 89.0
SM-9.0 E [Notes 1,2,3]	2.0-5.0	75-80	70-85	16	0.6-1.3	65	7	100	≤ 89.0
SM-9.5 A [Notes 1,2,3]	2.0-5.0	73-79	68-84	15	0.6-1.2	65	7	100	≤ 90.5
SM-9.5 D [Notes 1,2,3]	2.0-5.0	73-79	68-84	15	0.6-1.2	65	7	100	≤ 89.0
SM-9.5 E [Notes 1,2,3]	2.0-5.0	73-79	68-84	15	0.6-1.2	65	7	100	≤ 89.0
SM-12.5 A [Notes 1,2,3]	2.0-5.0	70-78	65-83	14	0.6-1.2	65	7	100	≤ 90.5
SM-12.5 D [Notes 1,2,3]	2.0-5.0	70-78	65-83	14	0.6-1.2	65	7	100	≤ 89.0
SM-12.5 E [Notes 1,2,3]	2.0-5.0	70-78	65-83	14	0.6-1.2	65	7	100	≤ 89.0
IM-19.0 A [Notes 1,2,3]	2.0-5.0	69-76	64-81	13	0.6-1.2	65	7	100	≤ 90.5
IM-19.0 D [Notes 1,2,3]	2.0-5.0	69-76	64-81	13	0.6-1.2	65	7	100	≤ 89.0
IM-19.0 E [Notes 1,2,3]	2.0-5.0	69-76	64-81	13	0.6-1.2	65	7	100	≤ 89.0
BM-25.0 A [Notes 2, 3, 4]	1.0-4.0	67-87	67-92	12	0.6-1.3	65	7	100	≤ 89.0
BM-25.0 D [Notes 2, 3, 4]	1.0-4.0	67-87	67-92	12	0.6-1.3	65	7	100	≤ 89.0

[1] SM = Surface Mix; IM = Intermediate Mixture; BM = Base Mixture

Note 1: Asphalt content should be selected at 4.0 % Air Voids.
Note 2: During production of an approved job mix, the VFA shall be controlled within these limits.
Note 3: Fines-Asphalt Ratio is based on effective asphalt content.
Note 4: Base mix shall be designed at 2.5 percent air voids. BM-25.0 A shall have a minimum asphalt content of 4.4 percent, unless otherwise approved by the Engineer. BM-25.0 D shall have a minimum asphalt content of 4.6 percent, unless otherwise approved by the Engineer.

Figure 9-1: Mix Design Criteria for Mix Types for Asphalt Concrete Mixtures

Table II-14A. Recommended Performance Grade of Asphalt Cement

Mix Type	Percentage of Reclaimed Asphalt Pavement (RAP) in Mix		
	% RAP ≤ 20.0	20.0% < % RAP ≤ 30%	20.0% < %RAP ≤ 35%
SM-9.0A, SM-9.5A, SM-12.5A	PG 64-22	PG 64-22	
SM-9.0D, SM-9.5D, SM-12.5D	PG 70-22	PG 64-22	
IM-19.0A	PG 64-22	PG 64-22	
IM-19.0D	PG 70-22	PG 64-22	
BM-25.0A	PG-64-22		PG 64-22
BM-25.0D	PG 70-22		PG 64-22

Figure 9-2: Recommended Performance Grades of Asphalt Cement

Physical Characteristics to be Determined by Testing

This section highlights basic terms and concepts that are critical to understanding the physical characteristics that will be determined by testing and why they are important.

	DEFINITIONS. The following terms will be used throughout this section:
Total asphalt content	The amount of asphalt binder that must be added to the mixture to produce the desired mix qualities.
Effective asphalt content	The amount of asphalt binder not absorbed by the aggregate.
Absorptiveness	The ability of the aggregate used in the mix to absorb asphalt binder.

Asphalt Binder Content

The proportion of asphalt binder in the mixture is critical and must be accurately determined in the laboratory and precisely controlled on the job. The optimum asphalt binder content of a mix is highly dependent on aggregate characteristics such as gradation and absorptiveness. The finer the mix gradation, the larger the total surface area of the aggregate; therefore, the greater the amount of binder required, as illustrated by the table below.

Asphalt Binder Content	Aggregate Gradation	Aggregate Absorptiveness
High	Fine	High
Low	Coarse	Low

Effective asphalt binder content—Effective asphalt binder content is the amount of binder not absorbed by the aggregate. In other words, it is the amount of asphalt that effectively forms a bonding film on the aggregate surfaces. Effective asphalt binder content is calculated by subtracting the amount of absorbed binder from the total binder content. This may be expressed as

- A percent by mass, the Percent Binder Effective (P_{be})
- A percent by volume, the Volume Binder Effective (V_{be}).

The absorptiveness of an aggregate is obviously an important consideration in determining the asphalt binder content of a mixture. This characteristic is generally known for established aggregate sources, but requires careful testing when new aggregate sources are used.

AWARENESS/IMPORTANT	
⚠️	Variations in binder content will cause changes in mix properties, from dry to wet. If a mix contains *too little* or *too much* mineral filler, arbitrary adjustments to correct the situation are likely to worsen it. Instead, proper sampling and testing should be done to determine the cause of the variations and, if necessary to establish a new job mix design.
Highlights a step in the procedure which is either unusual or very particular to this procedure. May also indicate awareness (additional information) or a cautionary concern in the procedure.	

Absorptiveness—The absorptiveness (ability to absorb asphalt) of the aggregate used in the mix is critical in determining optimum asphalt content. Enough asphalt must be added to the mix to allow for absorption and still coat the particles with an adequate film. When discussing absorbed and unabsorbed asphalt, technologists talk about the following two types of asphalt content:

- Total asphalt content—the amount of asphalt binder that must be added to the mixture to produce the desired mix qualities
- Effective asphalt content—the amount of asphalt binder not absorbed by the aggregate.

Aggregate Gradation

Aggregate gradation is directly related to optimum asphalt binder content. The finer the mix gradation, the larger the total surface area of the aggregate and the greater the amount of binder required to uniformly coat the particles. Conversely, because coarser mixes have less total aggregate surface area, they demand less binder. The relationship between aggregate surface area and optimum binder content is most pronounced where filler material is involved (i.e., very fine aggregate fractions which pass through the No. 200 (0.075 mm) sieve).

Testing is important because small increases in the amount of filler in a gradation can absorb much of the asphalt binder, resulting in a dry, unstable mix. Small decreases have the opposite effect—too little filler results in too rich (wet) a mixture.

Voids in the Total Mixture (VTM)

Air voids are small airspaces or pockets of air that occur between the coated aggregate particles in the final compacted mix. A certain percentage of air voids is necessary in all dense-graded highway mixes to allow for some additional pavement compaction under traffic and to provide spaces into which small amounts of binder can flow during this subsequent compaction.

AWARENESS/IMPORTANT	
⚠️	The allowable percentage of air voids (in *laboratory* specimens) is between 2.0% and 5.0% for most VDOT mixes. *Job* specifications require pavement that allows as low an air void content as is practical, approximately 8.0%.
Highlights a step in the procedure which is either unusual or very particular to this procedure. May also indicate awareness (additional information) or a cautionary concern in the procedure.	

The durability of an asphalt pavement is a function of the air void content. This is because the lower the air voids, the less permeable the mixture becomes. Too high an air void content provides passageways through the mix for the entrance of damaging air and water. A low air void content, on the other hand, can lead to flushing, a condition in which excess asphalt squeezes out of the mix to the surface. Density and void content are directly related. The higher the density, the lower the percentage of voids in the mix, and vice versa.

Voids Total Mixture (VTM) is the part of the compacted mixture not occupied by aggregate or asphalt, expressed as a percentage of the total volume. It is synonymous with air voids and is the complement of the percent density when based upon the Maximum Specific Gravity (G_{mm}). The VTM obtained in the Superpave mix design gives an indication of whether the mix can be compacted adequately in the field.

AWARENESS/IMPORTANT
⚠️ The VTM is probably the number one criterion for predicting field compaction and, ultimately, pavement life.
Highlights a step in the procedure which is either unusual or very particular to this procedure. May also indicate awareness (additional information) or a cautionary concern in the procedure.

Voids in the Mineral Aggregate (VMA)

Voids in the Mineral Aggregate (VMA) are the air void spaces that exist between the aggregate particles in a compacted paving mixture, including spaces filled with asphalt.

VMA represents the space that is available to accommodate the asphalt and the volume of air voids necessary in the mixture, as shown in Figure 9-3.

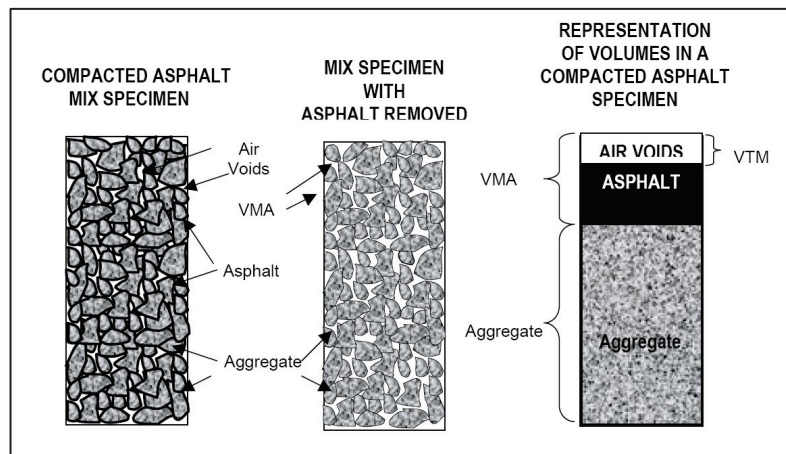The more VMA in the dry aggregate, the more space is available for the film of asphalt.

Figure 9-3: VMA in a Compacted Mix Specimen

The thicker the asphalt film on the aggregate particles, the more durable the mix. Specific minimum requirements for VMA are specified in Section 211.03 of the *Road and Bridge Specifications*.

AWARENESS/IMPORTANT
⚠️ Minimum VMA values must be adhered to so that a durable asphalt film thickness can be achieved.
Highlights a step in the procedure which is either unusual or very particular to this procedure. May also indicate awareness (additional information) or a cautionary concern in the procedure.

AWARENESS/IMPORTANT
⚠️ Increasing the density of gradation of the aggregate to a point where below-minimum VMA values are obtained leads to thin films of asphalt and a dry looking, low durability mix. Therefore, economizing in asphalt content by lowering VMA is actually counter-productive and detrimental to pavement quality.
Highlights a step in the procedure which is either unusual or very particular to this procedure. May also indicate awareness (additional information) or a cautionary concern in the procedure.

Voids Filled with Asphalt (VFA)

VFA is the percentage of voids in the compacted aggregate mass (VMA) that are filled with asphalt cement. It is synonymous with the Asphalt Void Ratio. The VFA property is important not only as a measure of relative durability, but also because there is an excellent correlation between it and percent density. If the VFA is too low, there is not enough asphalt to provide durability and the mix will be prone to fatigue. If the VFA is too high, then the available VMA has been overfilled with asphalt and the mix will be prone to over-densification under traffic and will lose stability. Thus, the VFA is a very important design property.

Fines to Asphalt Ratio (F/A)

The Fines to Asphalt Ratio (F/A) is an indication of the film thickness of coated particles. The film thickness helps reduce premature aging and moisture damage.

Tensile Strength Ratio (TSR)

This test measures the strength loss resulting from damage caused by "stripping" under laboratory controlled accelerated freeze-thaw conditioning. The results may be used to predict long-term susceptibility to stripping of an asphalt concrete. To combat the effects of water damage, an anti-stripping additive is used in all asphalt mixes. One of these additives is hydrated lime.

The Contractor may use either 1.0% hydrated lime in accordance with Section 211.02 (i) of the *Road and Bridge Specifications* or an approved chemical anti-strip additive at the manufacturer's recommended dosage. Approved chemical anti-strip additives are listed on the Department's approved list found in the Materials Division's *Manual of Instructions*. A combination of both hydrated lime and chemical anti-strip may be used to meet the TSR requirements.

The TSR value is determined in accordance with AASHTO T- 283 (including a freeze-thaw cycle). The TSR test is covered in detail in the Asphalt Plant Mix Design class.

AWARENESS/IMPORTANT
⚠️ For production tests, the mixture shall produce a tensile strength ratio (TSR) value not less than 0.80 for Superpave mixes.
Highlights a step in the procedure which is either unusual or very particular to this procedure. May also indicate awareness (additional information) or a cautionary concern in the procedure.

Testing Procedures

SAFETY WARNING
These standards and test methods may involve hazardous materials, operations and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.
Describes a condition where personal safety may be at risk. This is used to alert personnel to operating procedures & practices which, if not observed, may result in personal injury.

When a plant has produced a mixture, the mixture must be tested to ensure that it meets VDOT specifications. In addition, the Contractor's payment for the mixture produced will be based on the asphalt content and aggregate gradation determined by testing. The following will provide the necessary information for laboratory testing of plant produced mixtures (as described in Chapter 10).

Procedure for Determining Asphalt Content (Percent Binder) (VTM-102)

The Virginia Test Method (VTM) for determining the asphalt binder content in asphalt mixtures is the Ignition Method, VTM-102. This test method uses an ignition oven to burn off the asphalt binder in the mixture, leaving the aggregate behind.

The binder content of the mix will be used to determine the VMA and the F/A ratio of the mixture. When preparing a sample for testing by the Ignition Method, the quartering method, as specified in AASHTO T-248, may be used. The complete VTM-102 is in Appendix C of this manual.

Procedure for Compacting Specimen (AASHTO T-312)

The purpose of compacting specimens is to prepare them for the Bulk Specific Gravity (G_{mb}) test, which will ultimately be used to determine the air voids of the mixture.

TOOLS AND EQUIPMENT
Primary equipment used for this test includes the gyratory compactor, specimen molds, filter paper, thermometers, pans for each specimen and a scoop.
Describes what tools, equipment and tests are required to complete the job safely and with the highest level of quality.

<u>How to Mold Specimens</u>

To prepare and compact (i.e., mold) three test specimens for use in the Bulk Specific Gravity test, complete the steps that follow.

STEP 1. Turn the gyratory compactor on and let it warm-up.

     a. Once the gyratory compactor has cycled through the warm-up period, make sure it has the correct settings (e.g., the number of gyrations, ram pressure).
     b. The gyrations used for compacting specimens are found in Section 211.03 Table II-14.

STEP 2. Heat the molds to the desired compaction temperature as specified in Section 211.03 (d) 6.

STEP 3. Place the mixture in an oven set at the desired compaction temperature. Place a thermometer into the mixture so its temperature can be monitored.

STEP 4. Once the material has become workable, weigh out the desired amount of material for each of the three specimens.

STEP 5. Using a flat bottom scoop, place each specimen in a small pan with a thermometer in each of the pans to monitor temperature.

STEP 6. Heat each specimen to compaction temperature.

STEP 7. After the mixture has reached the compaction temperature, place a heated mold on a table and insert a piece of filter paper into the bottom of the mold.

STEP 8. Place the material into the mold in one lift, as shown in Figure 9-4. Place a piece of filter paper onto the top of the material. If needed, place the top plate into the mold.

STEP 9. Place the mold into the gyratory compactor and press the start button.

STEP 10. Once compaction is complete, check to make sure the specimen height is 115 ± 5 mm.


Figure 9-4: Insert Material into Mold

STEP 11. Remove the mold from the gyratory compactor, as shown in Figure 9-5. Extract the specimen and remove the filter paper from the top and bottom of the specimen.

STEP 12. Place the specimen on a smooth, flat surface and allow to cool to room temperature, as shown in Figure 9-6.

Repeat these steps as necessary for compacting additional specimens. Once the specimens have cooled, determine the Bulk Specific Gravity of the specimens using the procedure detailed on the next page.

Figure 9-5: Remove Mold from Gyrator
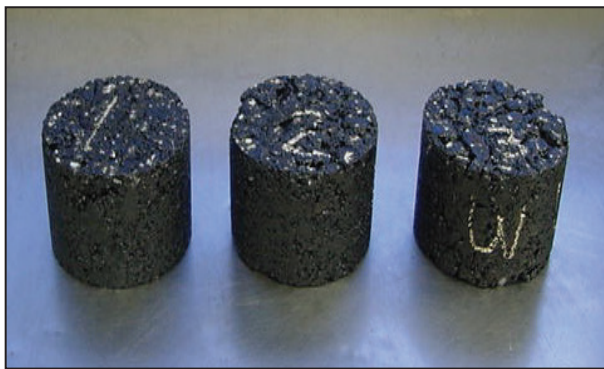
Figure 9-6: Place Specimen on Smooth, Flat Surface to Cool

Procedure for Determining Bulk Specific Gravity (AASHTO T-166)

TOOLS AND EQUIPMENT
Primary equipment used for this procedure includes a scale for weighing the core and water.
Describes what tools, equipment and tests are required to complete the job safely and with the highest level of quality.

How to Determine Bulk Specific Gravity

To determine the Bulk Specific Gravity of the compacted cores in accordance with AASHTO T-166 Method A, complete the steps that follow.

STEP 1. Dry the specimen to a constant mass. (Note: this step is typically intended for field compacted specimens that may have been exposed to moisture).

- Constant mass shall be defined as the mass at which further drying at 125 ± 5 °F (52 ± 3 °C) does not alter the mass by more than 0.05%.
- Samples saturated with water shall initially be dried overnight at 125 ± 5 °F (52 ± 3 °C) and then weighed at two-hour drying intervals.
- Recently-molded laboratory samples which have not been exposed to moisture do not require drying.

STEP 2. Cool the specimen to room temperature at 77 ± 9 °F (25 ± 5 °C).

STEP 3. Weigh the core in the air, and record the mass (**A**).

STEP 4. Immerse each specimen in water at 77 ± 3 °F (25 ± 1 °C) for 4 ± 1 minutes and record the immersed mass (**C**).

STEP 5. Remove the specimen from the water and quickly damp dry the specimen by blotting with a damp towel, as shown in Figure 9-7.

STEP 6. Weigh to determine the saturated - surface dry mass (SSD), and record the mass (**B**).

Note: Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen.

Figure 9-7: Blot with Damp Towel

STEP 7. Calculate the Bulk Specific Gravity of each specimen using the following equation:

$$\text{Bulk Specific Gravity (}G_{mb}\text{) of Core} = \frac{A}{B - C}$$

Where: **A** = Mass of Core in Air
B = Saturated - Surface Dry Mass of Core in Air
C = Mass of Core in Water

STEP 8. Calculate the average Bulk Specific Gravity of the mix (G_{mb}) using the following equation:

$$\text{Average } G_{mb} = \frac{G_{mb} \text{ Speciman 1} + G_{mb} \text{ Speciman 2} + G_{mb} \text{ Speciman 3}}{3}$$

The average G_{mb} will be used to determine air voids (VTM) of the mixture.

Procedure for Determining Maximum Specific Gravity (AASHTO T-209)

TOOLS AND EQUIPMENT
Primary equipment used for this procedure includes a Rice bucket, scale, and vacuum.
Describes what tools, equipment and tests are required to complete the job safely and with the highest level of quality.

The Maximum Specific Gravity (G_{mm} or Rice) is determined by AASHTO T-209 (Rice Method), in which vacuuming is used to extract all of the air from the mixture. This represents 100% density (no air voids) for a particular asphalt mixture. This value is used in conjunction with the Bulk Specific Gravity to determine the relative density and VTM of the compacted specimens for that mixture.

How to Determine Maximum Specific Gravity (G_{mm})

Complete the steps that follow to determine the Maximum Specific Gravity.

STEP 1. After quartering or splitting a mixture to obtain the sample mass needed for the particular mixture, spread the mix out on a table to cool, as shown in Figure 9-8.

Be sure to separate the mix particles so that there are no particles larger than 1/4 inch.

STEP 2. Weigh the Rice bucket in air and record the mass (**A**).

STEP 3. Place the sample in the Rice bucket, as shown in Figure 9-9.

Figure 9-8: Spread the Mix Out to Cool

STEP 4. Weigh the sample and the bucket together in air and record the mass (**C**).

STEP 5. Add water to the sample in the bucket until the sample is completely covered with water.
   a. The temperature of the water must be 77 °F (25 °C).
   b. If the temperature is not 77 °F, the temperature correction factor must be used.

Figure 9-9: Place Sample in the Bucket

STEP 6. Place the top on the Rice bucket and pull the vacuum to 27.75 ± 2.25 mm HG, as Figure 9-10 illustrates, to remove the air voids in the mix.

STEP 7. Maintain the vacuum for 15 ± 2 minutes, shaking the bucket at 2-minute intervals, or place the bucket on a slow continuous shaker.

STEP 8. After 15 ± 2 minutes, release the vacuum, remove the top, and place the bucket suspended in the bath for 10 ± 1 minutes, as shown in Figure 9-11. The water in this bath must also be 77 °F (25 °C)

STEP 9. After 10 ± 1 minute, record the mass of the sample and bucket in water (**D**).
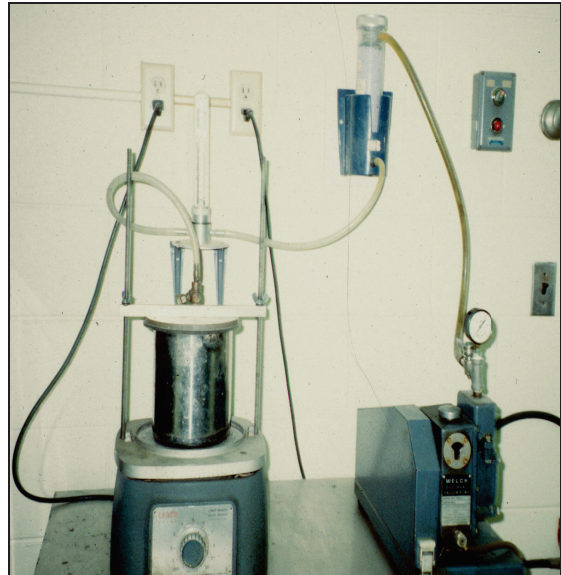

Figure 9-10: Place Bucket in Vacuum

STEP 10. After recording this mass, gently pour water from bucket back into water bath and dispose of sample in bucket (you will no longer need the sample).

STEP 11. Then place the empty bucket back into the water bath, leaving it immersed for 10 ± 1 minutes.

STEP 12. Record the mass of the empty bucket in water (**B**).

STEP 13. Calculate the Maximum Specific Gravity (G$_{mm}$) using the following equation:

Figure 9-11: Place the Bucket in a Water Bath

$$G_{mm} = \frac{(C - A)}{(C - A) - (D - B)}$$

Where: **A** = Mass of Container in air
B = Mass of Container in water
C = Mass of Container and Sample in air
D = Mass of Container and Sample in water

Procedure for Determining Tensile Strength Ratio (AASHTO T 283)

The test is performed by compacting specimens to an air void level of 6% to 8%. Three specimens are selected as a control and tested without moisture conditioning. Three more specimens are selected to be conditioned by saturating with water, undergoing a freeze cycle, and subsequently having a warm-water soaking cycle.

The specimens are then tested for indirect tensile strength by loading the specimens at a constant rate and measuring the force required to break the specimen. The tensile strength of the conditioned specimens is compared to the control specimens to determine the tensile strength ratio (TSR). This test may also be performed on cores taken from the finished pavement.

Procedure for Conducting the Boil Test (VTM-13)

TOOLS AND EQUIPMENT
Primary equipment used for this procedure includes a burner, flask and paper towel.
Describes what tools, equipment and tests are required to complete the job safely and with the highest level of quality.

In the Boil Test, asphalt mixtures are subjected to the action of boiling water for a specified period of time, to determine the effectiveness of an anti-stripping additive when it has been used in asphalt mixtures. The Boil Test is performed in accordance with VTM-13. The results are reported as "Pass" or "Fail."

How to Conduct the Boil Test

To perform the Boil Test, complete the steps that follow.

STEP 1. Allow the sample of asphalt mixture to cool to 230 ± 9 °F (110 ± 5 °C).

STEP 2. Sieve approximately 800 grams of material over the 1/2 inch (12.5 mm) sieve, then sample 400 grams of the remaining material for the test.

Note: Remove plus 1/2 inch (12.5 mm) material from mixture prior to attaining specified temperature.

STEP 3. Place approximately 200 grams on a paper towel before boiling. Place the remainder (approximately 200 grams) of the mixture in boiling water and continue boiling for 10 minutes, as shown in Figure 9-12.

Figure 9-12: Place the Mixture in Boiling Water

STEP 4. Drain the water from the mixture and place the sample on a paper towel, as shown in Figure 9-13. Allow to cool at room temperature overnight.

STEP 5. The next morning, compare the boiled and not boiled portions on the paper towels, as shown in Figure 9-14.
  a. If the boiled portion shows more signs of stripping than the not boiled portion, the test fails.
  b. The producer will then take a second sample and test using the same steps as before. If the second sample fails, production shall be halted until corrective action is taken to the satisfaction of the Engineer.
  c. On the resumption of production, samples will be taken immediately and tested using the same steps as described above.

STEP 6. Report as passing or failing.

Figure 9-13: Place the Mixture on a Paper Towel
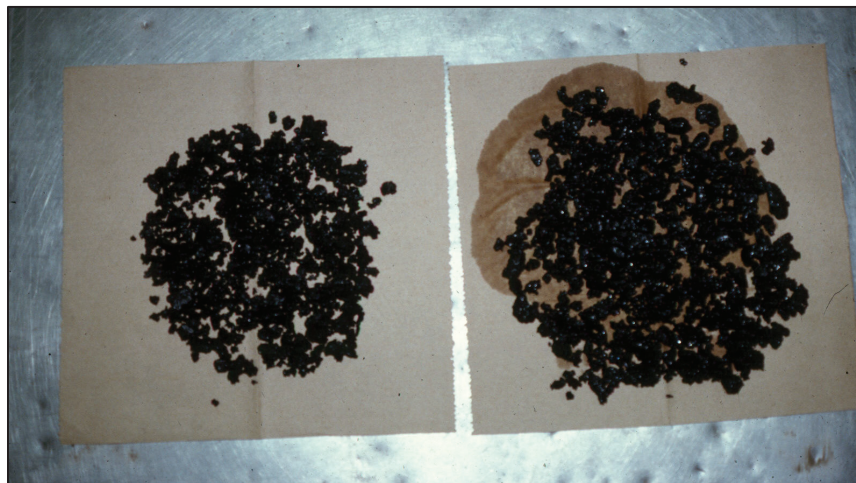
Figure 9-14: Look for Signs of Stripping

Calculating Volumetric Properties

To determine the volumetric properties (VTM, VMA, VFA, F/A) of the mixture, the Bulk Specific Gravity of the mixture (G_{mb}), Maximum Specific Gravity (G_{mm}) of the mixture, Asphalt Binder Content, and Aggregate Gradation first must be determined. In addition, the Effective Specific Gravity of the aggregate (G_{se}) and the Bulk Specific Gravity of the aggregate (G_{sb}) must be calculated.

Definitions used in the formulas and calculations:

G_{mm}   = Maximum Specific Gravity of Mixture (Rice)
G_{mb}   = Bulk Specific Gravity of Mixture
G_{se}   = Effective Specific Gravity of Aggregate
G_b   = Binder (Asphalt) Specific Gravity
G_{sb}   = Bulk Specific Gravity of Aggregate
P_b   = Percent Binder (Asphalt) Content
P_{be}   = Effective Binder (Asphalt) Content
P_s   = Percent Stone (100 – Pb)
CF   = Field correction factor supplied with job mix formula

Effective Specific Gravity of Aggregate (G_{se}):

$$G_{se} = \frac{P_s}{\left(\frac{100}{G_{mm}}\right) - \left(\frac{P_b}{G_b}\right)}$$

Where:

G_{se} = Effective Specific Gravity of aggregate
P_b = Percent Binder (from Ignition Method)
P_s = Percent Stone (100 – P_b from Ignition Method)
G_{mm} = Maximum Specific Gravity of mixture (from Rice Method)
G_b = Binder Specific Gravity (1.030)

Bulk Specific Gravity of Aggregate (G_{sb}):

$$G_{sb} = G_{se} - CF$$

Where:

G_{sb} = Bulk Specific Gravity of aggregate
G_{se} = Effective Specific Gravity of aggregate
CF   = Field correction factor supplied with job mix formula

Once these properties have been determined, the volumetric properties (VTM, VMA, VFA, and F/A) can be calculated as follows.

VTM:

Determine the voids in the total mixture (VTM) using the following formula:

$$VTM = 100 \times \left[1 - \left(\frac{G_{mb}}{G_{mm}} \right) \right]$$

Where:

G_{mb} = Bulk Specific Gravity of mixture

G_{mm} = Maximum Specific Gravity of mixture (from Rice Method)

This VTM value will used to determine density and VFA.

Relative Density or (%Gmm) :

The relative density of each test specimen can be determined by the following formula:

$$\%G_{mm} = 100 \times \left(\frac{G_{mb}}{G_{mm}} \right)$$

VMA:

Determine the voids in the mineral aggregate (VMA) using the following formula:

$$VMA = 100 - \left[\frac{(G_{mb} \times P_s)}{G_{sb}} \right]$$

Where:

G_{mb} = Bulk Specific Gravity of mixture

P_s = Percent stone (100 – Pb from Ignition Method)

G_{sb} = Bulk Specific Gravity of aggregate

VFA:

Determine the voids filled with asphalt (VFA) using the following formula:

$$VFA = \left[\frac{(VMA - VTM)}{VMA} \right] \times 100$$

F/A Ratio:

Determine the F/A ratio as follows:

1. Determine the percent passing the No. 200 (75 mm) sieve from sieve analysis of mixture.
2. Calculate the Effective Specific Gravity of the aggregate (G_{se}) and Bulk Specific Gravity of the aggregate (G_{sb}).
3. Calculate the Percent Binder Effective of the mixture (P_{be}).

$$P_{be} = P_b - \left[(P_s \times G_b) \quad \times \quad \left(\frac{(G_{se} - G_{sb})}{(G_{se} \times G_{sb})} \right) \right]$$

Where:

P_{be}	= Percent Binder Effective
P_b	= Percent Binder(from Ignition Method)
P_s	= Percent stone (100 – Pb)
G_b	= Binder specific gravity (1.030)
G_{se}	= Effective Specific Gravity of Aggregate
G_{sb}	= Bulk Specific Gravity of Aggregate

4. Calculate F/A ratio.

$$\text{F/A ratio} = \frac{\% \text{ passing } 200}{P_{be}}$$

Example Volumetric Calculations

The example that follows illustrates the proper use of the various volumetric calculations. In the example, the results of laboratory testing are as follows:

- The percent binder (P_b) of the mixture after performing the Ignition Method is 4.60%.
- The field correction factor submitted with the job mix formula is 0.021.
- The percent passing the No. 200 sieve is 5.0%.

Maximum Specific Gravity (G_{mm}) Procedure

Variable Assignment			Specimen Mass
Mass Bucket in Air (g)	=	A	2089.5
Mass of Bucket in Water (g)	=	B	1343.7
Mass of Bucket and Sample in Air (g)	=	C	3432.7
Mass of Bucket and Sample in Water (g)	=	D	2137.5

Maximum Specific Gravity (G_{mm}):

$$G_{mm} = \frac{C - A}{(C - A) - (D - B)}$$

$$G_{mm} = \frac{3432.7 - 2089.5}{(3432.7 - 2089.5) - (2137.5 - 1343.7)}$$

$$G_{mm} = \frac{1343.2}{(1343.2 - 793.8)}$$

$$G_{mm} = \frac{1343.2}{549.4}$$

$$G_{mm} = \mathbf{2.445}$$

Bulk Specific Gravity (G$_{mb}$) Procedure

Variable Assignment		Specimen #1 Mass	Specimen #2 Mass	Specimen #3 Mass
Mass of Core in Air (g)	= **A**	1188.7	1183.1	1184.6
SSD Mass of Core (g)	= **B**	1196.2	1191.0	1192.1
Mass of Core in Water(g)	= **C**	677.4	672.8	672.8

Bulk Specific Gravity of Mixture (G$_{mb}$):

$$\text{Bulk Specific Gravity (B}_{SG}) \text{ of Core } = \frac{A}{(B - C)}$$

$$\begin{array}{c} G_{mb} \\ \text{Core 1} \end{array} \qquad \frac{1188.7}{(1196.2 - 677.4)} = \frac{1188.7}{518.8} = \mathbf{2.291}$$

$$\begin{array}{c} G_{mb} \\ \text{Core 2} \end{array} \qquad \frac{1183.1}{(1191.0 - 672.8)} = \frac{1183.1}{518.2} = \mathbf{2.283}$$

$$\begin{array}{c} G_{mb} \\ \text{Core 3} \end{array} \qquad \frac{1184.6}{(1192.1 - 672.8)} = \frac{1184.6}{519.3} = \mathbf{2.281}$$

The Average Bulk Specific Gravity of the cores is the Bulk Specific Gravity of the mixture (G$_{mb}$):

$$\text{Avg. } G_{mb} = \frac{G_{mb} \text{ Specimen 1} + G_{mb} \text{ Specimen 2} + G_{mb} \text{ Specimen 3}}{3}$$

$$\text{Avg. } G_{mb} = \frac{2.291 + 2.283 + 2.281}{3} = \frac{6.855}{3} = \mathbf{2.285}$$

Effective Specific Gravity of Aggregate (Gse):

$$G_{se} = \frac{P_s}{\left(\dfrac{100}{G_{mm}}\right) - \left(\dfrac{P_b}{G_b}\right)}$$

$$G_{se} = \frac{100 - 4.6}{\left(\dfrac{100}{2.445}\right) - \left(\dfrac{4.6}{1.03}\right)}$$

$$G_{se} = \frac{95.4}{40.9 - 4.5}$$

$$G_{se} = \frac{95.4}{36.4} = \mathbf{2.621}$$

Bulk Specific Gravity of Aggregate (G$_{sb}$):

$$G_{sb} = G_{se} - CF$$
$$G_{sb} = 2.621 - 0.021$$
$$G_{sb} = \mathbf{2.600}$$

Voids in Total Mix :

$$VTM = 100 \times \left[1 - \left(\frac{Avg.\ G_{mb}}{G_{mm}} \right) \right]$$

$$VTM = 100 \times \left[1 - \left(\frac{2.285}{2.445} \right) \right]$$

$$VTM = 100 \times (1 - 0.935)$$

$$VTM = 100 \times 0.065 = \mathbf{6.5\%}$$

Voids in Mineral Aggregate:

$$VMA = 100 - \left(\frac{\text{Avg. } G_{mb} \times P_s}{G_{sb}} \right)$$

$$VMA = 100 - \left(\frac{2.285 \times 95.4}{2.600} \right)$$

$$VMA = 100 - \frac{217.989}{2.600}$$

$$VMA = 100 - 83.84 = \mathbf{16.2}$$

Voids Filled with Asphalt:

$$VFA = \left[\left(\frac{VMA - VTM}{VMA} \right) \right] \times 100$$

$$VFA = \left(\frac{16.2 - 6.5}{16.2} \right) \times 100$$

$$VFA = \frac{9.7}{16.2} \times 100$$

$$VFA = 0.599 \times 100 = \mathbf{60}$$

F/A Ratio:

$$\text{F/A Ratio} = \frac{\text{\% passing 200 sieve}}{P_{be}}$$

$$P_{be} = P_b - \left[(P_s \times G_b) \times \left(\frac{G_{se} - G_{sb}}{G_{se} \times G_{sb}} \right) \right]$$

$$P_{be} = 4.6 - \left[\left((100 - 4.6) \times 1.03 \right) \times \left(\frac{2.621 - 2.600}{2.621 \times 2.600} \right) \right]$$

$$P_{be} = 4.6 - \left[(95.4) \times 1.03 \times \left(\frac{0.021}{6.815} \right) \right]$$

$$P_{be} = 4.6 - \left[(98.262) \times (0.003) \right]$$

$$P_{be} = 4.6 - 0.29$$

$$P_{be} = \mathbf{4.31}$$

$$\text{F/A Ratio} = \frac{\text{\% passing 200 sieve}}{P_{be}}$$

$$\text{F/A Ratio} = \frac{5.0}{4.31}$$

$$\text{F/A Ratio} = \mathbf{1.16}$$

Volumetric Properties Worksheets and Formulas

The following section contains reference materials (worksheets and formulas) to assist you in making required volumetric calculations. Note that all measurements in this section are in grams (g).

Volumetric Worksheets

The following worksheets are presented in this section:

- Worksheet for Determining the Maximum Specific Gravity of the Mixture

- Worksheet for Determining the Bulk Specific Gravity of the Mixture

- Worksheet for Determining the Percent Voids in the Total Mixture

- Worksheet for Determining the Effective Gravity of the Aggregate

- Worksheet for Determining the Bulk Specific Gravity of the Aggregate

- Worksheet for Determining the Voids in the Mineral Aggregate

- Worksheet for Determining the Voids Filled with Asphalt

- Worksheet for Calculating the F/A Ratio

Worksheet for Determining the Maximum Specific Gravity of the Mixture (G_{mm})

Maximum Specific Gravity of the Mixture
$$G_{mm} = \frac{C - A}{(C - A) - (D - B)}$$

Variable Assignment		Specimen Mass
Mass of the Container in Air	= A	875.5
Mass of the Container in Water	= B	458.8
Mass of the Container & Sample in Air	= C	2161.8
Mass of the Container & Sample in Water	= D	1236.3

$$G_{mm} = \frac{\underline{} - }{(-) - (-)}$$

$$G_{mm} = \frac{\overline{}}{(-)}$$

$$G_{mm} = \frac{\overline{}}{}$$

$$G_{mm} =$$

Worksheet for Determining the Bulk Specific Gravity of the Mixture (G_{mb})

Bulk Specific Gravity (G_{mb}) of Core = $\dfrac{A}{(B - C)}$

Where: **A** = Mass of Core in Air

B = Saturated - Surface Dry Mass of Core in Air

C = Mass of Core in Water

Bulk Specific Gravity of the Mixture

Variable Assignment		Specimen #1 Mass	Specimen #2 Mass	Specimen #3 Mass
Mass of Core in Air	= A	4653.5	4662.5	4622.5
SSD Mass of Core in Air	= B	4662.8	4672.7	4631.7
Mass of Core in Water	= C	2745.4	2749.6	2730.2

Specimen #1

$$G_{mb} = \dfrac{\rule{4cm}{0.4pt}}{(\quad - \quad)}$$

$$G_{mb} = \dfrac{\rule{4cm}{0.4pt}}{}$$

$$G_{mb} =$$

Specimen #2

$$G_{mb} = \dfrac{\rule{4cm}{0.4pt}}{(\quad - \quad)}$$

$$G_{mb} = \dfrac{\rule{4cm}{0.4pt}}{}$$

$$G_{mb} =$$

Specimen #3

$$G_{mb} = \dfrac{\rule{4cm}{0.4pt}}{(\quad - \quad)}$$

$$G_{mb} = \dfrac{\rule{4cm}{0.4pt}}{}$$

$$G_{mb} =$$

Calculate Average Bulk Specific Gravity (Avg. $_{Gmb}$)

$$\text{Avg. } G_{mb} = \frac{G_{mb} \text{ Specimen 1} + G_{mb} \text{ Specimen 2} + G_{mb} \text{ Specimen 3}}{3}$$

$$\text{Avg. } G_{mb} = \frac{\quad + \quad + \quad}{3}$$

$$\text{Avg. } G_{mb} = \frac{\quad\quad}{3}$$

$$\text{Avg. } G_{mb} = $$

Worksheet for Determining the Percent Voids in the Total Mixture (VTM)

Variable Assignment	Specimen Mass	
Avg. G_{mb} (Average Bulk Sp. Gr. of the Mix)	=	2.427
G_{mm} (Maximum Sp. Gr. of the Mix)	=	2.528

$$VTM = 100 \times \left[1 - \left(\frac{\text{Avg. } G_{mb}}{G_{mm}} \right) \right]$$

$$VTM = 100 \times \left[1 - \left(\underline{\hspace{2cm}} \right) \right]$$

$$VTM = 100 \times \left[1 - \left(\underline{\hspace{2cm}} \right) \right]$$

$$VTM = 100 \times \left[1 - \right]$$

$$VTM = 100 \times$$

$$VTM =$$

Worksheet for Determining the Effective Specific Gravity of the Aggregate (G$_{se}$)

$$G_{se} = \frac{P_s}{\left(\dfrac{100}{G_{mm}}\right) - \left(\dfrac{P_b}{G_b}\right)}$$

Where	Equals
P$_b$	5.65%
G$_{mm}$	2.528
G$_b$	1.030
P$_s$	100 − Pb

$$G_{se} = \frac{\rule{4cm}{0.4pt}}{\left(\dfrac{100}{\rule{1cm}{0.4pt}}\right) - \left(\dfrac{\rule{1.5cm}{0.4pt}}{}\right)}$$

$$G_{se} = \frac{\rule{4cm}{0.4pt}}{(\quad - \quad)}$$

$$G_{se} = \rule{4cm}{0.4pt}$$

$$G_{se} =$$

Worksheet for Determining the Bulk Specific Gravity of the Aggregate (Gsb)

G_{sb} = G_{se} - CF   (field correction factor from job mix formula)

Where	Equals
CF	0.026
G_{se}	2.769

G_{sb} =   −

G_{sb} =

Worksheet for Determining the Voids in the Mineral Aggregate (VMA)

VMA uses the Average G_{mb} (Bulk Specific Gravity of Mixture) for the three test specimens.

$$VMA = 100 - \left[\frac{(\text{Avg. } G_{mb} \times P_s)}{G_{sb}} \right]$$

Where	Equals
Avg. G_{mb} (Average Bulk Sp. Gr. of Mix)	2.427
G_{sb} (Bulk Sp. Gr. of the Agg.)	2.743
P_s (Percent Stone)	94.35

$$VMA = 100 - \left[\frac{(\underline{\quad\quad} \times \underline{\quad\quad})}{\underline{\quad\quad\quad\quad}} \right]$$

$$VMA = 100 - \left[(\underline{\quad\quad\quad\quad}) \right]$$

$$VMA = 100 -$$

$$VMA =$$

Worksheet for Determining the Voids Filled with Asphalt (VFA)

VFA uses the average VTM for the three specimens.

$$VFA = \left[\frac{(VMA - VTM)}{VMA} \right] \times 100$$

Where	Equals
VMA	16.5%
VTM	4.0%

$$VFA = \left[\frac{(\underline{\hspace{2cm}} - \underline{\hspace{2cm}})}{\underline{\hspace{4cm}}} \right] \times 100$$

$$VFA = \underline{\hspace{3cm}} \times 100$$

VFA =

Worksheet for Calculating the F/A Ratio:

1. Determine the % passing the No. 200 sieve from sieve analysis of the mixture.

$$\text{F/A Ratio} \quad = \quad \frac{\% \text{ passing No. 200 sieve}}{P_{be}}$$

2. Calculate the P_{be} (Percent Binder Effective) of the mixture.

$$P_{be} = P_b - \left[(P_s \times G_b) \times \left(\frac{(G_{se} - G_{sb})}{(G_{se} \times G_{sb})} \right) \right]$$

Where	Equals
P_b = Percent Binder Content from Ignition Method	5.65%
P_s = Percent Stone	$(100 - P_b)$
G_b = Binder (asphalt) Specific Gravity	1.030
G_{se} = Effective Specific Gravity of Aggregate	2.769
G_{sb} = Bulk Specific Gravity of Aggregate	2.743

$$P_{be} = \quad - \left[(\quad \times \quad) \times \left(\frac{(\quad - \quad)}{(\quad \times \quad)} \right) \right]$$

$$P_{be} = \quad - \left[(\quad) \times \left(\frac{(\quad)}{(\quad)} \right) \right]$$

$$P_{be} = \quad - \left[(\quad) \times (\quad) \right]$$

$$P_{be} = \quad -$$

$$P_{be} =$$

$$\text{F/A Ratio} \quad = \quad \frac{\text{\% passing No. 200 sieve}}{P_{be}}$$

Where	Equals
% passing the No. 200 sieve	5.9%
P_{be}	5.36%

F/A Ratio = ─────────────────

F/A Ratio =

Volumetric Properties Formulas

Use these formulas in calculating volumetric properties for asphalt. Definitions used in formulas:

G_{mm} = Maximum Specific Gravity of Mixture (Rice)

G_{mb} = Bulk Specific Gravity of Mixture

G_{se} = Effective Specific Gravity of Aggregate

G_b = Binder (Asphalt) Specific Gravity

G_{sb} = Bulk Specific Gravity of Aggregate

P_b = Percent Binder (Asphalt) Content

P_{be} = Effective Binder (Asphalt) Content

P_s = Percent Stone ($100 - Pb$)

Maximum Specific Gravity (G_{mm})

A = Mass of Bucket in Air
B = Mass of Bucket in Water
C = Mass of Bucket and Sample in Air
D = Mass of Bucket and Sample in Water

$$G_{mm} = \frac{(C - A)}{(C - A) - (D - B)}$$

Bulk Specific Gravity of Core (G_{mb})

A = Mass of Core in Air
B = SSD Mass of Core in Air
C = Mass of Core in Water

$$\frac{A}{(B - C)}$$

Average Bulk Specific Gravity of Cores

(Avg. G_{mb}) = Sum of G_{mb} Cores / Number of Cores

$$\text{Avg. } G_{mb} = \frac{G_{mb} \text{ Specimen 1} + G_{mb} \text{ Specimen 2} + G_{mb} \text{ Specimen 3}}{3}$$

VTM (% Voids in Total Mix)

$$VTM = 100 \times \left[1 - \left(\frac{G_{mb}}{G_{mm}} \right) \right] \qquad \text{Avg. } VTM = 100 \times \left[1 - \left(\frac{\text{Avg. } G_{mb}}{G_{mm}} \right) \right]$$

Relative Density or (%G$_{mm}$):

$$\% \, G_{mm} = 100 \times \left(\frac{G_{mb}}{G_{mm}} \right) \qquad\qquad Avg. \, \% \, G_{mm} = 100 \times \left(\frac{Avg. \, G_{mb}}{G_{mm}} \right)$$

Effective Specific Gravity of Aggregate (G$_{se}$)

$$G_{se} = \frac{P_s}{\left(\frac{100}{G_{mm}} \right) - \left(\frac{P_b}{G_b} \right)}$$

Bulk Specific Gravity of Aggregate (G$_{sb}$)

$$G_{sb} = G_{se} - CF$$

VMA (% Voids in the Mineral Aggregate)

$$VMA = 100 - \left[\frac{(Avg. \, G_{mb} \times P_s)}{G_{sb}} \right]$$

VFA (% Voids Filled with Asphalt)

$$VFA = \left[\frac{(VMA - VTM)}{VMA} \right] \times 100$$

F/A Ratio (Fines to Effective Asphalt Ratio)

$$P_{be} = P_b - \left[(P_s \times G_b) \times \left(\frac{(G_{se} - G_{sb})}{(G_{se} \times G_{sb})} \right) \right]$$

$$F/A \, Ratio = \frac{\% \, passing \, \#200 \, sieve}{P_{se}}$$

Chapter Nine Knowledge Check

1. The Ignition Method test utilizes a sample of Asphalt Concrete taken from the truck.
   A. True
   B. False

2. The Ignition Oven is the method used to determine the Percent Binder or Asphalt Content in asphalt mixtures.
   A. True
   B. False

3. The Virginia test method for determining the Percent Binder or Asphalt Content in asphalt mixtures is the centrifuge method.
   A. True
   B. False

4. The actual test sample of an asphalt mixture used in the Ignition Oven shall be a minimum of 1500 grams for an SM-12.5A mix.
   A. True
   B. False

5. What is the purpose of the Ignition Method?

6. Specifications allow what percent voids in the total mix for an SM-12.5A?

7. VFA are voids in a filler aggregate in asphalt mixtures.
   A. True
   B. False

8. VMA are voids in a mineral aggregate.
   A. True
   B. False

9. Asphalt test procedures can be found in the appropriate AASHTO procedure or Virginia Test Method (VTM).
   A. True
   B. False

10. _____ is added to asphalt as an anti-stripping agent.

11. The _____ Test checks the effectiveness of an anti-stripping additive.

Practice Problem 1: Volumetric Calculations

The results of laboratory testing of a SM-9.5A yielded the following results:

Percent Binder= 5.05

Correction Factor = .017

Asphalt Binder Specific Gravity = 1.030

Percent minus 200 = 4.5

1. Complete the following tables.

Maximum Specific Gravity of Mix (G_{mm}):

Variable Assignment		Grams
Mass Container in Air	=A	741.2
Mass Container in Water	=B	647.2
Mass Container and Sample in Air	=C	2724.6
Mass Container and Sample in Water	=D	1852.8
Maximum Specific Gravity (G_{mm})	=	

Bulk Specific Gravity of Mix (G_{mb}):

Variable Assignment		Specimen 1	Specimen 2	Specimen3
Mass of Specimen in Air	=A	4797.7	4790.8	4791.1
SSD Mass of Specimen	=B	4799.5	4792.6	4792.9
Mass of Specimen in Water	=C	2830.7	2828.5	2828.0
Specimen Bulk Specific Gravity				
Average G_{mb} =				

2A. Calculate the Effective Specific Gravity of the Aggregate (G_{se}) = _____

2B.   Calculate the Bulk Specific Gravity of the Aggregate (G_{sb})   = _____

3.   Calculate the VTM, VMA, VFA and F/A ratio for this mix.

4.   Do all the volumetric properties meet the mix design criteria for this mix during production?

Design Range Criteria	Specification Criteria	Calculated Results	Meet Spec.?
VTM			
VMA			
VFA			
F/A			

Practice Problem 2: Volumetric Calculations

The results of laboratory testing of a SM-12.5D yielded the following results:

Percent Binder= 5.01

Correction Factor = .018

Asphalt Binder Specific Gravity = 1.030

Percent minus 200 = 6.2

1. Complete the following tables.

Maximum Specific Gravity of Mix (G_{mm}):

Variable Assignment		Grams
Mass Container in Air	=A	745.9
Mass Container in Water	=B	651.2
Mass Container and Sample in Air	=C	2779.4
Mass Container and Sample in Water	=D	1875.0
Maximum Specific Gravity (G_{mm})	=	

Bulk Specific Gravity of Mix (G_{mb}):

Variable Assignment		Specimen 1	Specimen 2	Specimen3
Mass of Specimen in Air	=A	4793.7	4792.9	4789.0
SSD Mass of Specimen	=B	4799.2	4796.1	4791.9
Mass of Specimen in Water	=C	2845.5	2846.5	2844.2
Specimen Bulk Specific Gravity	=			
Average G_{mb} =				

2A.   Calculate the Effective Specific Gravity of the Aggregate (G_{se})   = _____

2B.   Calculate the Bulk Specific Gravity of the Aggregate (G_{sb})   = _____

3.   Calculate the VTM, VMA, VFA and F/A ratio for this mix.

4.   Do all the volumetric properties meet the mix design criteria for this mix during production?

	Design Range Criteria	Specification Criteria	Calculated Results	Meet Spec.?
VTM				
VMA				
VFA				
F/A				

Practice Problem 3: Volumetric Calculations

The results of laboratory testing of an IM-19.0A yielded the following results:

Percent Binder= 5.40

Correction Factor = .023

Asphalt Binder Specific Gravity = 1.030

Percent minus 200 = 6.0

1. Complete the following tables.

Maximum Specific Gravity of Mix (G_{mm}):

Variable Assignment		Grams
Mass Container in Air	=A	746.9
Mass Container in Water	=B	651.2
Mass Container and Sample in Air	=C	2923.9
Mass Container and Sample in Water	=D	1956.7
Maximum Specific Gravity (G_{mm})	=	

Bulk Specific Gravity of Mix (G_{mb}):

Variable Assignment		Specimen 1	Specimen 2	Specimen3
Mass of Specimen in Air	=A	4790.5	4791.4	4789.1
SSD Mass of Specimen	=B	4795.0	4794.9	4792.4
Mass of Specimen in Water	=C	2810.0	2813.3	2809.2
Specimen Bulk Specific Gravity	=			
Average G_{mb} =				

2A. Calculate the Effective Specific Gravity of the Aggregate (G_{se})   = _____

2B.   Calculate the Bulk Specific Gravity of the Aggregate (G_{sb})   = _____

3.   Calculate the VTM, VMA, VFA and F/A ratio for this mix.

4.   Do all the volumetric properties meet the mix design criteria for this mix during production?

Design Range Criteria	Specification Criteria	Calculated Results	Meet Spec.?
VTM			
VMA			
VFA			
F/A			

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